5.16.57 DETERMINATION OF ASPHALT CONTENT AND GRADATION OF HOT MIX ASPHALT CONCRETE BY THE IGNITION METHOD (Kansas Test Method KT-57)

a. SCOPE

a.1. This test method covers the determination of asphalt content of hot mix paving mixtures by ignition of the asphalt cement at 932°F (500°C) in a furnace. The aggregate remaining after burning can be used for sieve analysis using **KT-34**.

a.2. The values in metric units are to be regarded as the standard.

a.3. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

b. REFERENCED DOCUMENTS

b.1. KT-1; Sampling Aggregates

b.2. KT-25; Sampling Plant Mixed Hot Mix Asphalt (HMA)

b.3. KT-26; Sampling Asphalt Materials

b.4. KT-34; Sieve Analysis of Extracted Aggregate

b.5. AASHTO M 231; Weighing Devices Used in the Testing of Materials

b.6. AASHTO T 308; Determining the Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method

b.7. Manufacturer's instruction manual

c. SUMMARY OF TEST METHODS

c.1. The asphalt cement in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt content is calculated as the difference between the initial mass of the asphalt paving mixture and the mass of the residual aggregate, and calibration factor. The asphalt content is expressed as mass percent.

d. SIGNIFICANCE AND USE

d.1. This method can be used for quantitative determinations of asphalt binder content and gradation in hot-mixed paving mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to **KT-34.**

e. SAMPLING

e.1. Obtain samples of aggregate in accordance with **KT-1**.

e.2. Obtain samples of freshly produced hot-mix asphalt in accordance with **KT-25**. Quarter the larger sample in the following manner[1]:

e.2.a. Spread a sheet of paper (Kraft or similar) on a hard, clean, smooth and level surface. Place the sample in a pile near the center of the paper and mix by alternately lifting each corner towards the opposite corner thereby rolling the mixture to the opposite corner. This should be performed in a vigorous manner. Placing the sample on a piece of cardboard and mixing thoroughly with a trowel is an acceptable alternate.

e.2.b. Divide the pile into four equal quarters with a straightedge (trowel or similar metal blade) and completely remove two pre-selected diagonally opposite quarters.

e.2.c. Continue this quartering procedure until the original sample is reduced to the approximately desired size. On the final quartering step, if the sample is too large before quartering, but will be too small after quartering, the sample pile is divided into equal opposite sectors but unequal adjacent sectors. This can be accomplished by varying the dividing angle at the center of the sample pile from the normal 90 degrees. Opposite sections can then be selected to obtain the desired sample size.

e.3. Obtain samples of asphalt cement in accordance with **KT-26**.

e.4. Preparation of Test Specimens:

e.4.a. Place the sample in a large flat pan and warm to 230 $\pm$ 9°F (110 $\pm$ 5°C) for a minimum of 30 minutes or until the sample is dried to a constant mass.

e.4.b. The size of the test sample shall be governed by the nominal maximum aggregate size[a] of the mixture and shall conform to the mass requirement shown in **table 5.16.57-01**. When the mass of the test specimen exceeds the capacity of the equipment used, the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt content (weighted average). Also, sample sizes should not be more than 400 g greater than the minimum recommended sample mass. Large samples of fine mixes tend to result in incomplete ignition of the asphalt.

Table 5.16.57-01

Nominal Max. Agg. Size, in (mm)	Min. Mass Specimen, g
3/8 in (9.5)	1200
1/2 in (12.5)	1500
3/4 in (19.0)	2000
1 in (25.0)	3000
1 1/2 in (37.5)	4000

[1] AASHTO TP-53 does not provide a complete description for splitting the sample as established in **e.2.**

NOTE a: Nominal maximum aggregate size is one size larger than the first sieve to retain more than 10 percent.

f. CALIBRATION

f.1. This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established by testing a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed.

f.2. The calibration should be repeated each time there is a change in the mix ingredients or design.

f.3. According to the requirements of **e.**, prepare two calibration samples at the design asphalt content. Prior to mixing, prepare a butter mix at the design asphalt content. The purpose of the butter mix is to condition the mixing bowl by providing a coating of asphalt and fines in the bowl. Mix and discard the butter mix prior to mixing any of the calibration specimens to ensure an accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season and designated to be used on the candidate project. In otherwords, this calibration process should not be completed until all necessary material has arrived on the project site. An additional "blank" specimen shall be batched and tested for aggregate gradation according to **KT-34**. The washed gradation shall fall within the mix design tolerances.

f.4. The freshly mixed specimens may be placed directly in the sample baskets. Allow the sample to cool to room temperature.

f.5. Test specimens in accordance with **g.** and **h.** (Test Method A) or **i.** and **j.** (Test Method B).

f.6. Perform a gradation analysis on the residual aggregate as indicated in **k.** Compare the gradation to the gradation of the unburned, "blank" specimen to evaluate the amount of aggregate breakdown. *This evaluation is for information only*.

f.7. Once all of the calibration specimens have been burned, determine the measured asphalt contents for each sample by calculation.

f.8. If the difference between the measured asphalt contents of the two samples exceeds 0.15 percent, repeat the two tests and, from the four tests, discard the high and low result. Determine the calibration factor (C_F) from the two remaining results (C_A and C_B). Calculate the difference between the measured and actual asphalt contents for each sample. The calibration is the average of the differences expressed in percent by mass of the asphalt mixture for Superpave designs and expressed in percent by mass of the remaining aggregate for Marshall designs.

g. APPARATUS (TEST METHOD A)

g.1. Ignition furnace - A forced air ignition furnace, capable of maintaining the temperature at 1072°F (578°C), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3500 g sample in addition to the sample baskets. A data collection system will be included so that the mass can be automatically determined and displayed during the test. The furnace shall have a built in computer program to calculate change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor,

corrected asphalt content (%), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate sample size of 3500 g. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

NOTE b: The furnace shall also allow the operator to change the ending mass loss percentage to 0.02 percent.

g.2. Sample basket(s) - of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE c: Screen mesh or other suitable material openings of approximately No.8 (2.36 mm) and No.30 (600 μm) has been found to perform well.

g.3. Catch Pan - of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

g.4. Oven - capable of maintaining 230 ± 9°F (110 ± 5°C).

g.5. Balance - of sufficient capacity and conforming to the requirements of AASHTO M 231, Class G2 for weighing specimen in basket(s).

g.6. Safety Equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C) and a protective cage capable of surrounding the sample baskets during the cooling period.

g.7. Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

h. TEST PROCEDURES (TEST METHOD A)

h.1. Preheat the ignition furnace to 932°F (500°C). Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

h.2. Oven dry field HMA samples to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C).

h.3. Enter the calibration factor for the specific mix to be tested in the ignition furnace as determined by section **f.**

h.4. Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

h.5. Prepare the sample as described in **e**. Record the initial mass while at room temperature. Evenly distribute this sample in the sample basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

h.6. Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

h.7. Input the initial mass of the specimen in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

h.8. Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample mass (including the basket(s)) displayed on the furnace scale equals the total mass recorded in **h.5.** within ± 5 g. Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

NOTE d: The furnace temperature will drop below the set point when the door is opened, but will recover when the door is closed and ignition occurs. Sample ignition typically increases the temperature well above the set point, depending on sample size and asphalt content.

h.9. Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

h.10. Open the chamber door, remove the sample basket(s) and allow them to cool to room temperature (approximately 30 minutes).

h.11. Once the sample has cool to room temperature, weigh and record the final mass. Calculate the uncorrected asphalt content, then apply correction factor to determine corrected asphalt content.

i. APPARATUS (TEST METHOD B)

i.1. Ignition Furnace - A forced air ignition furnace, capable of maintaining the temperature at 1072°F (578°C). The furnace chamber dimensions shall be adequate to accommodate a sample size of 3500 g. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

i.2. Sample basket(s) - of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE e: Screen mesh or other suitable material with openings of approximately No.8 (2.36 mm) and No.30 (600 μm) has been found to perform well.

i.3. Catch Pan - of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

i.4. Oven - capable of maintaining 230 ± 9°F (110 ± 5°C).

i.5. Balance - of sufficient capacity and conforming to the requirements of AASHTO M 231, Class G2.

i.6. Safety Equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C) and a protective cage capable of surrounding the sample baskets during the cooling period.

i.7. Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring samples after ignition, spatulas, bowls, and wire brushes.

j. TEST PROCEDURES (TEST METHOD B)

j.1. Preheat the ignition furnace to 932°F (500°C).

j.2. Oven dry the HMA sample to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C).

j.3. Record the calibration factor for the specific mix to be tested as determined in **f**.

j.4. Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

j.5. Prepare the sample as described in **e**. Place the sample baskets in the catch pan. Evenly distribute the sample in the basket(s) taking care to keep the material away from the edges.

j.6. Allow the sample to cool to room temperature. Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

j.7. Burn the HMA sample in the furnace for at least 40 minutes after the ignition oven has cycled thru the initial burn off phase.

NOTE f: The appropriate time for the initial burn of an HMA sample is dependent on sample size and aggregate material. For large samples, the time could be significantly longer than 40 minutes.

j.8. Remove the sample from the furnace after ignition and allow it to cool to approximately room temperature (at least 30 minutes).

j.9. Weigh and record the mass (W_A) of the sample after ignition to the nearest 0.1 g.

j.10. Repeat **f.7.** through **f.9.** until a visual inspection indicates complete burn-off has been accomplished. Adjust the 40 minute time so a single burnoff sequence is required. It may be necessary to cycle the sample through for an additional 10 minute program after the initial run. The material will appear free of asphalt (no small black asphalt particles intermixed in material) and the change in measured mass (W_A) does not exceed 0.1 percent of the initial mass (W_S). Additional burn time may indicate a need for a new filter. Filters have found to last two to four burn-offs.

j.11. Record the last value obtained for (W_A) as the mass (W_A) of the sample after ignition.

j.12. Calculate the asphalt content of the sample using one of the following equations:

j.12.a. For a Superpave design (total mass mix):

$$AC\% = \left[\frac{(W_s - W_A)}{W_s} X100\right] - C_F$$

where:

AC% = the measured (corrected) asphalt content percent by mass of the HMA sample.

W_A = the total mass of aggregate remaining after ignition.

W_s = the total mass of the HMA sample prior to ignition, and

C_F = calibration factor, percent by mass of HMA sample.

where:

$C_F = (C_A + C_B)/2$

C_A or C_B = measured asphalt content - actual asphalt content

where:

C_A & C_B = Individual sample correction factors, percent by mass of HMA sample as outlined in **f.8**.

j.12.b. For a Marshall mix design (dry aggregate method):

$$AC\% = \left[\frac{(W_s - W_A)}{W_A} X100\right] - C_F$$

where:

AC% = the measured (corrected) asphalt content percent by dry aggregate mass of the HMA sample.

k. GRADATION

k.1. Allow the specimen to cool to room temperature in the sample baskets.

k.2. Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

k.3. Perform the gradation analysis according to **KT-34**.

l. REPORT

Always report the test method (A or B), corrected asphalt content, calibration factor, temperature compensation factor (if applicable), total percent loss, sample mass and test temperature. Examples of a spreadsheet available for use with Method B are illustrated in **5.16.57-01** and **5.16.57-02**.

Precision Statement

Asphalt Content	Standard Deviation, Percent		Acceptable Range of Two Test Results, Percent	
	Methods		Methods	
	A	B	A	B
Single Operator Precision	0.04	0.12	0.11	0.36
Multi Lab Precision	0.06		0.17	

m. PRECISION AND BIAS

m.1. Precision - Precision was determined in an NCAT Round-Robin study for surface mixes using Test Method A. Precision for a single operator using Test Method B was determined at the Materials and Research Center.

NOTE g: The precision estimates are based on 4 aggregate types, 4 replicates, and 12 laboratories participating with 0 laboratory results deleted as outlying observations. All 4 aggregates were tested in surface mixes and had relatively low absorption values.

m.2. Bias: The bias for Test Methods A and B has not been determined.

5.16.57-01
Spreadsheet for Ignition Oven Calibration

CALIBRATION SECTION

Mix Type:	SM-1T	**Lab. No:**	98-50001
Project #:	75-56-K9229-01	**Sample Date:**	5/12/98
Sampled by:	John Smith	**Report Date:**	5/14/98
Field Engr:	Jane Doe	**Contractor:**	Jones and Sons Construction
Reprtd by:	John Smith	**Design No:**	98-D001

Sample Number	**1**	**2**
Actual % AC (g)	5.60	5.61
Measured % AC		
Mass of Sample (before) (g)	3230	3415
Mass of sample (after) (g)	3062	3234
Measured Correction Factor (Dry)	5.49	5.60
Measured Correction Factor (Wet)	5.20	5.30
Ind. Corr. Factor (Ca & Cb) [Dry]	-0.11	-0.01
Ind. Corr. Factor (Ca & Cb) [Wet]	-0.40	-0.31

Average Correction Factor (Cf) [Dry]	-0.06
Average Correction Factor (Cf) [Wet]	-0.35

5.16.57-02
Spreadsheet for Calculating Corrected Asphalt Content

TEST SECTION

Mix Type:	SM-1T	**Lab. No:**	98-50001
Project #:	75-56-K9229-01	**Sample Date:**	35927
Sampled by:	John Smith	**Report Date:**	35929
Field Engr:	Jane Doe	**Contractor:**	Jones and Sons Construction
Reprtd by:	John Smith	**Design No:**	98-D001

	EXTRACTION	GRADATION SIEVE SIZE	GMS RET.	% RET.
1. Mass Frame & Sample	7469.2	**1" (25.0mm)**		
2. Mass Frame	6208.0	**3/4" (19.0mm)**		
3. Mass of Sample (1-2)	1261.2	**1/2" (12.5mm)**		
4. Mass of Frame & Dry Agg.	7395.9	**3/8" (9.5mm)**		
5. Mass Loss (1-4)	73.3	**#4 (4.75mm)**		
6. Mass Of Dry Aggregate (4-2)	1187.9	**#8 (2.36mm)**		
7. Corr. Factor [Dry]	-0.06	**#16 (1.18mm)**		
8. Corr. Factor [Wet]	-0.35	**#30 (600um)**		
		#50 (300um)		
9. % Asphalt (Dry Agg.)	6.23	**#100 (50um)**		
		#200 (75um)		
10. % Asphalt (Total Mix)	6.17			
11. Total Time (Min.)	65			

Copies of the spreadsheets can be obtained from the Materials Quality Control Engineer at the Materials and Research Center. Spreadsheets are currently in Excel format.